A NEW BROADBAND REFLECTARRAY ANTENNA USING NOVEL SINGLE-LAYER ELEMENTS

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ABSTRACT

A novel single-layer reflectarray element for broadband use is proposed. Ansoft HFSS is used to analyze the reflection phase for the element. By varying the element size, a slow slope of the reflection phase curve with the phase range over 600° is achieved. A center-fed 121-element reflectarray antenna is designed using the proposed elements and a linearly polarized pyramidal horn antenna is used as the feed of the reflectarray. The simulated results show that the gain of 24.42dB at the center frequency of 13.58GHz with 3-dB gain bandwidth of 36.8% (from 11.08~16.08GHz), demonstrating a wideband performance compared to the conventional designs.

Index Terms— reflectarray, single-layer, broadband, center-fed

1. INTRODUCTION

Reflectarray antenna combines some of the features of the reflector antenna and the array antenna [1]. It has potential application in space based radar for its feature of flat, low cost, low profile, light weight, high efficiency, and high gain. However, the inherent characteristic of narrow bandwidth usually limits its application. For a microstrip reflectarray antenna, its bandwidth is limited by two factors [2]. One is the narrow bandwidth of the elements and the other is differential spatial phase delay.

Many researches have been done to improve the bandwidth of reflectarray [3-6]. In [3], a two-layer reflectarray with rectangular patches of variable size is demonstrated, and the results show a superior bandwidth performance compared with conventional single layer reflectarray. In [4], a disk element with attached phase-delay lines is presented. A reflectarray is designed using the elements and the 3-dB gain bandwidth close to 18 percent is achieved. A prime-focus reflectarray with elements of a rectangular patch and a rectangular ring is present in [5]. The measured results show that 1-dB gain bandwidth reaches 30%. In [6], a new phase-shifting element is present and a large bandwidth (18%) in simulation is obtained. By replacing the usual layer of near-resonant patches with an artificial impedance surface consisting of closely spaced electrically patches on a grounded dielectric substrate, the 1-dB gain bandwidths of the reflectarray is over 20 percent[7].

In this paper, a novel single-layer element structure for bandwidth improvement is presented. The reflection phase curse is obtained by varying the element size and 600° reflection phase range has been achieved. Then, a center-fed 121-element

reflectarray is designed using the proposed elements. The simulated 3-dB gain bandwidth of 36.8% (11.08~16.08GHz) has been achieved at the center frequency of 13.58GHz.

2. ELEMENT DESIGN

The configuration of the proposed reflectarray element is composed of four quarter circles and a quasi crossed dipole, as shown in Fig.1. The length of quasi crossed dipole is *a*. The four quarter circles are identical with the radius of *r*. The gap between the quarter circles and quasi crossed dipole is *g*. The elements are assumed to be printed on a dielectric substrate with relative permittivity of 2.25 and thickness of *h*. The lattice period of the element *L* is 13mm, which equals 0.59 wavelengths at 13.58GHz.

The phase response is obtained by varying the element size. The relationships between *r, g* and *a* are assumed as $r=k*a$ and $g=k_1*a$. After optimizing the dimension parameters, the final design parameters are as follows: k=0.432, k_1=0.048, h =2mm. The element is simulated using Ansoft HFSS, and master-slave boundaries with Floquet ports are defined to analyze the reflection characteristics.

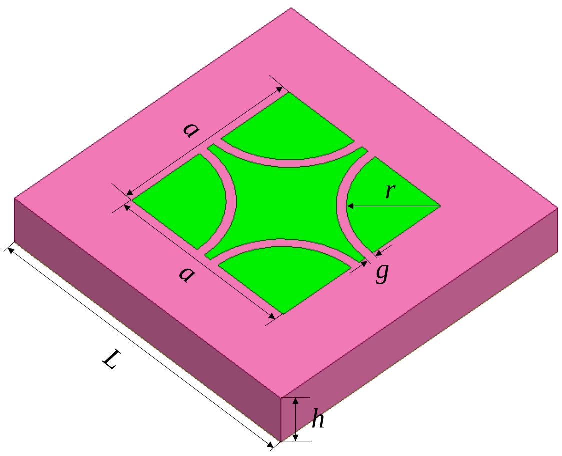

Fig. 1 The element structure

Fig. 2 shows the reflection phase response of the element for different values of incident angles at 13.58GHz. It can be concluded that the incident angle has little influence on the phase response when it is no more than 30°. Fig. 3 shows the reflection phase response versus the length of quasi crossed dipole *a* for different frequencies (11.58~15.58GHz). It can be seen in Fig. 3 that the reflection phase range of the element reaches 600° at 13.58GHz, which is larger than the minimum required range of 360°.

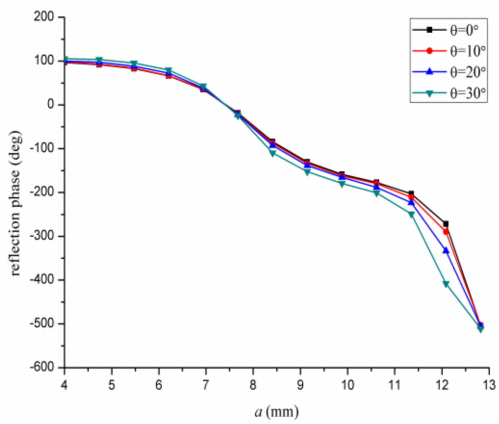

Fig. 2 Reflection phase response of the element for different values of incident angles at 13.58GHz

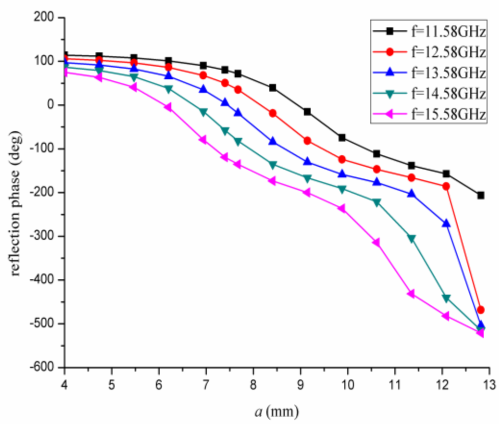

Fig. 3 Reflection phase response for different frequencies

3. REFLECTARRAY DESIGN AND RESULTS

A center-fed 121-element reflectarray using the proposed element is designed and simulated. The design is based on the phase response performance at 13.58GHz. The reflectarray is designed to generate a beam in the broadside direction. Fig. 4 presents the model of the proposed reflectarray antenna. A linearly polarized pyramidal horn antenna is designed as the feed of the reflectarray. The radiation patterns of the pyramidal horn antenna at 13.58GHz are shown in Fig. 5. The distance between the phase center of the horn antenna and the reflectarray is 143mm, which is equivalent an F/D ratio of 1. Fig. 6 shows the simulated radiation patterns of the reflectarray antenna in E-plane and H-plane at the center frequency of 13.58GHz, it can be concluded that the simulated gain is 24.42dB at the center frequency of 13.58GHz. The simulated gain of reflectarray and feed horn against frequencies from 10.58GHz to 17.08GHz are shown in Fig. 7, which exhibits 3-dB gain bandwidth about 36.8% (11.08~16.08GHz).

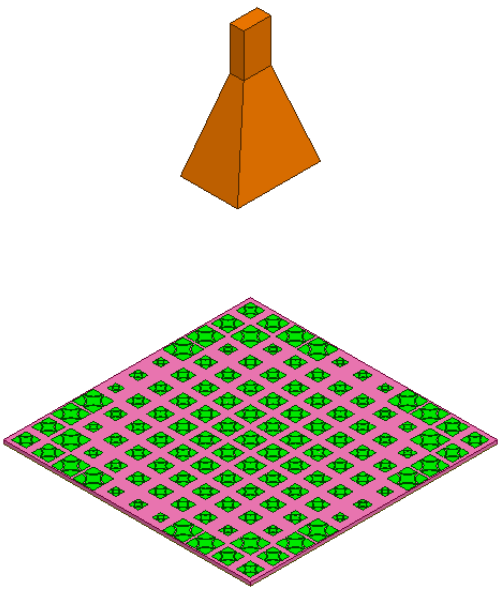

Fig. 4 The model of the proposed reflectarray antenna

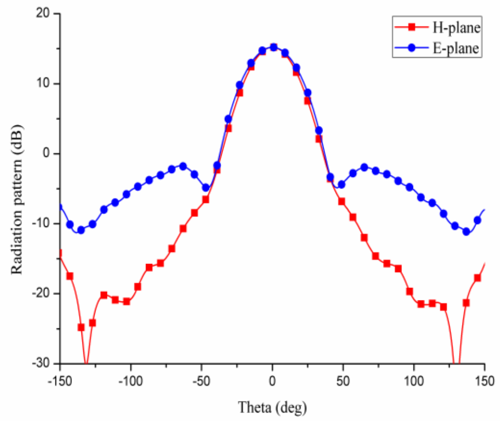

Fig. 5 Radiation pattern of the feed at center frequency (13.58GHz)

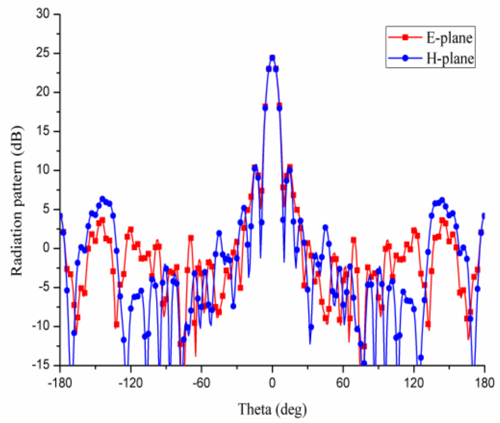

Fig. 6 The simulated radiation pattern of the reflectarray antenna

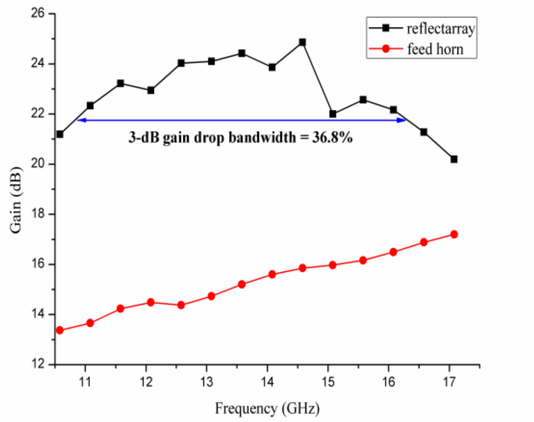

Fig. 7 Gain of the reflectarray and the feed horn antenna versus frequency

4. CONCLUSION

A novel single-layer reflectarray element structure for bandwidth improvement is proposed. The reflection phase curve shows sufficient phase variation range with a wide range of frequency band. By using the element a center-fed 121-element reflectarray operating at 13.58GHz has presented. A pyramidal horn antenna is used as the feed of the reflectarray. The simulated results show that a 3-dB gain bandwidth of 36.8% is achieved. An experimental verification will be performed in the next step.

5. REFERENCES

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